CHAPTER 4

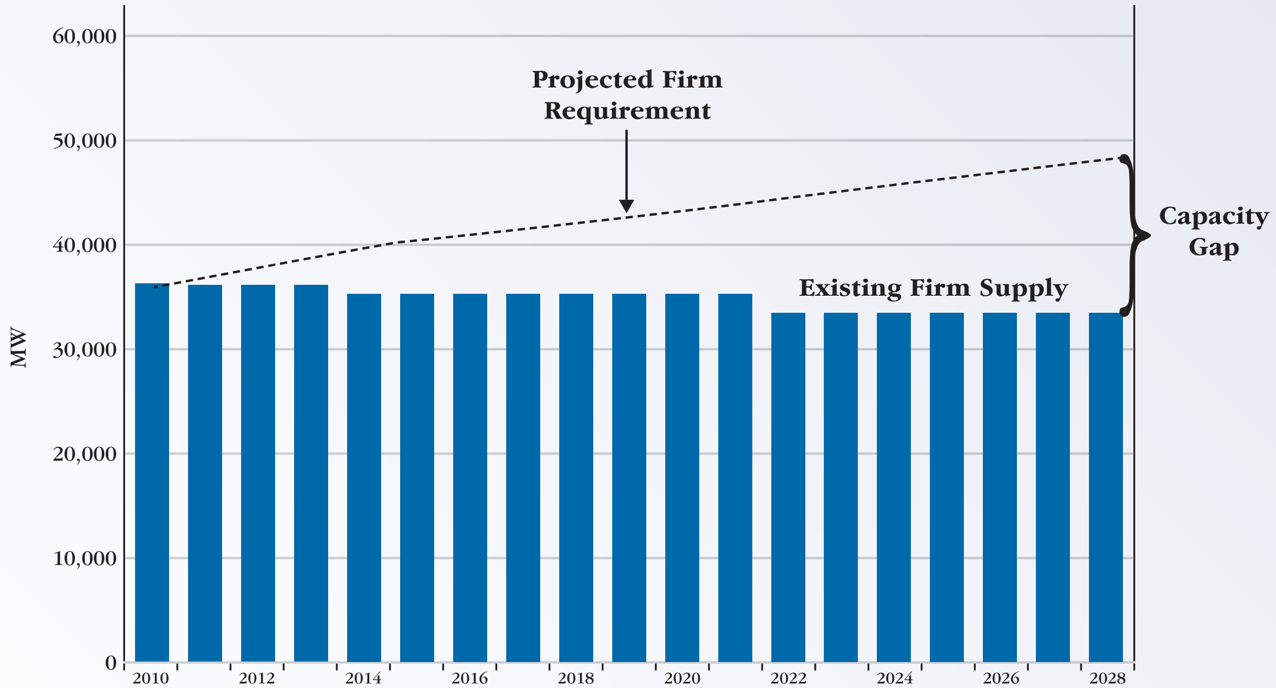
TVA is gearing up to meet the increased energy demands of growing cities throughout the Southeast, as evidenced by this photo of downtown Nashville at night.

Increasing TVA's production from cleaner energy sources like wind, solar and nuclear are at the core of the overall strategy for the future.

Estimating the Capacity Gap

Projected Firm Requirements are TVA's forecasted electricity requirements to meet demand over time.

Capacity Gap is the difference between total supply and total demand for electricity.



Existing Firm Supply is TVA's existing energy resources to meet projected electricity demand.

4 Need for Power Analysis

The need for power analysis determines the ability of TVA's existing energy resources to meet projected electricity demand. It defines the capacity gap which is the difference between supply and demand over the IRP study period. These needs will continue to vary from season to season, day to day and even minute to minute. For the purposes of this IRP, the need for power was analyzed through 2029.

The execution of this analysis included the following four steps:

1. Estimate demand
2. Determine reserve capacity needs
3. Estimate supply
4. Estimate capacity gap

Demand
+ Reserve Capacity
– Supply
____
Capacity Gap

4.1 Estimate Demand

Determination of a need for power begins with long-term forecasts of the growth in demand for electricity, both in terms of electricity sales to the end-user and the peak demands those end-users place on the TVA system. These forecasts were developed from individual, detailed forecasts of residential, commercial and industrial sales, which served as the basis for all resource and financial planning activities. Historical forecast accuracy was monitored to ensure errors in data or methodology were quickly identified and fixed. A range of forecasts (high, expected and low) were also generated to ensure that TVA's plans were not too dependent on the accuracy of a single forecast. The following sections provide more detail on the processes used to develop the forecasted demand.

4.1.1 Load Forecasting Methodology

TVA's load forecasting is a complex process that starts with the best available data and is carried out using both econometric (statistical economic) and end-use models. TVA's econometric models link electricity sales to several key economic factors in the market, such as the price of electricity, the price of competing energy source options and the growth in overall economic activity. Specific values for key variables were used to develop forecasts of sales growth in the residential and commercial sectors, as well as in each industrial sector. Underlying trends within each sector, such as the use of various types of equipment or processes, played a major role in forecasting sales.

To capture these trends, along with expected changes in the stock and efficiency of equipment and appliances, TVA used a variety of end-use forecasting models. For example, in the residential sector, sales were forecasted for space heating, air conditioning, water heating and several other uses after accounting for important factors (i.e., changes in efficiency over time, appliance saturation and replacement rates and growth in the average size of the American home). In the commercial sector, a number of categories, including lighting, cooling, refrigeration and space heating, were examined with a similar attention to changes in important variables such as efficiency and saturation.

Since forecasting is inherently uncertain, TVA supplemented its modeling with industry analyses and studies of specific major issues that may have the potential to impact those forecasts. TVA also produced alternative regional forecasts based on different outcomes for key drivers (i.e., economic growth, population growth and economic behaviors) of some of TVA's largest wholesale customers. Two of these alternative forecasts, referred to as the "high-load" and "low-load" forecasts, defined a range of possible future outcomes with a high level of confidence that the true outcome will fall within this range. This ensured that TVA's resource planning took into account the variability that is the hallmark of year-to-year peak demand and energy sales.

Several key inputs were used as drivers of the long-term forecasts of residential, commercial and industrial demand. The most important of these were economic activity, the price of electricity, customer retention and the price of other sources of energy such as natural gas. These key inputs are described in the following sections.

Economic Activity

Periodically, but at least annually, TVA produces a forecast of regional economic activity for budgeting, long-range planning and economic development purposes. These forecasts are based on national forecasts developed by internationally recognized economic forecasting services.

The economy of the TVA service territory has historically been more dependent on manufacturing than the United States on average. Industries such as pulp and paper, aluminum, steel and chemicals have been drawn to the region because of the wide availability of natural resources, access to a skilled workforce and the supply of reliable and affordable electricity. In recent years, regional growth has outpaced national growth as manufacturing activities have grown at a faster pace than non-manufacturing activities. However, this can also mean that in periods of recession, regional growth will contract faster and more sharply given this relatively higher degree of dependence on manufacturing. As evidenced by the ongoing recovery from the most recent recession, the regional economy tends to recover more quickly and robustly.

Future growth is expected to be lower than historical averages as a result of the impacts of the recent recession and ongoing recovery as well as the trend of declining U.S. manufacturing intensity. As markets for manufacturing industries have become global in reach, production capacity has moved overseas from the TVA region for many of the same industries. The decline in demand associated with these off-shore industries has been offset to some degree by the continued growth of the automobile industry in the Southeast over the last 20 years. The TVA region is expected to retain its comparative advantage in the automotive industry, as exemplified by the new Volkswagen auto plant under construction in Chattanooga, Tenn. However, reduced long-term prospects for the U.S. automotive industry will also have an impact on the regional industry.

Other impacts from the recent recession such as increased financial market regulation and tighter credit conditions may also work toward restraining economic growth. These impacts could continue in the long-term resulting in a slowdown in future economic growth for the TVA region and nation.

Despite the impacts of a slowed economy, population growth in the Tennessee Valley region continues to be strong. Most movement into the region is still primarily driven by economic opportunities in the contracting sectors and other expanding sectors in the region. Part of this growth is to serve the existing population (i.e., retail and other services), but, more importantly, a large part of this growth is related to export services that are sold to areas outside the region. Notable examples are corporate headquarters such as Nissan (automobile manufacturing) in Franklin, Tenn., Hospital Corporation of America (the largest private operator of hospitals in the world) in Nashville, Tenn. and FedEx, AutoZone, International Paper and Service Master in Memphis, Tenn.

In addition, the Tennessee Valley has become an attractive region for the growing ranks of America's retirees looking for a moderate climate and a more affordable region than traditional retirement locations and is increasingly fueled as Baby Boomers exit the workforce. The increase in the retiree population has a multiplier effect in the service sector, increasing the need for employees to meet growing demand.

Customer Retention

In the last 20 years, the electric utility industry has undergone a fundamental change in most parts of the nation. In many states, an environment of regulated monopoly has been replaced with varying degrees of competition.

While TVA has contracts with the 155 distributors of TVA power, it is not immune to competitive pressures. The contracts allow distributors to give TVA notice of contract cancellation, after which they may procure power from other sources. Many of TVA's large directly served customers have the option to shift production from plants in the TVA service area to plants in other utilities' service territories if TVA's rates become non-competitive.

The spring 2010 forecast expected TVA's average price of electricity to remain competitive with the rates of other utilities. As a result, the net impact of competition in the medium forecast is that TVA will retain the majority of its current customer base.

Price of Electricity

Forecasts of the retail price for electricity are based on long-term estimates of TVA's total costs to operate and maintain the power system and are adjusted to include an estimate of the historical markups charged by distributors of TVA power. These costs, known in the industry as revenue requirements, are based on estimates of the key costs of generating and delivering electricity, including fuel, variable operations and maintenance costs, capital investment and interest. High and low electricity price forecasts are also derived using high and low values for these same factors after accounting for any relationships that may exist between variables.

Price of Substitute Fuels

Considering electricity is a source of energy, the service derived from consuming electricity can also be obtained, where applications allow, using other sources of energy. If the price of electricity is not competitive with the price of other fuels that can provide the same energy services as electricity, such as water and space heating, customers may move away from electricity in the long-term and substitute cheaper sources of energy. The potential for this type of substitution will depend on the relative prices of other fuels, the ability of the fuel to provide a comparable service and the physical capability to make the change. For example, while consumers can take action to change out electric water heaters and replace electric heat pumps with natural gas furnaces, the ability to utilize another form of energy to power consumer electronics, lighting and many appliances is far more limited by current technology.

Changes in the price of TVA's electricity compared to the price of natural gas and other fuels will influence consumers' choices of appliances—either electric, gas or other fuels. While other substitutions are possible, natural gas prices serve as the benchmark for determining substitution impacts in the load forecasts.

4.1.2 Forecast Accuracy

Forecast accuracy is generally measured in part by error in the forecasts, whether day ahead, year ahead, or multiple years ahead. Figures 4-1 and 4-2 show annual forecasts from 2000 through 2010 for peak load requirements and net system requirements. Figure 4-1 is a comparison of actual and forecasted summer peak demand in MW. Figure 4-2 is a comparison of actual and forecasted net system requirements in GWh. Note that the "Norm.Actual" line represents the normalized value of the annual energy, meaning abnormal weather impacts have been removed.

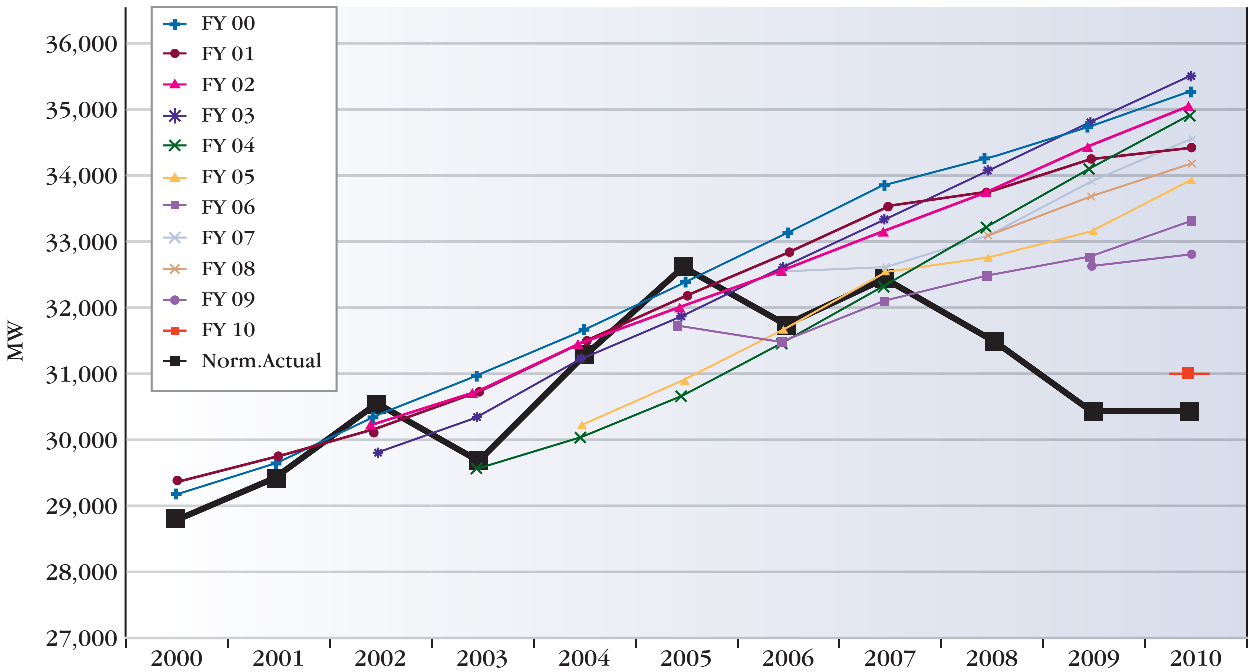


Figure 4-1 – Comparison of Actual and Forecasted Summer Peak Demand (MW)

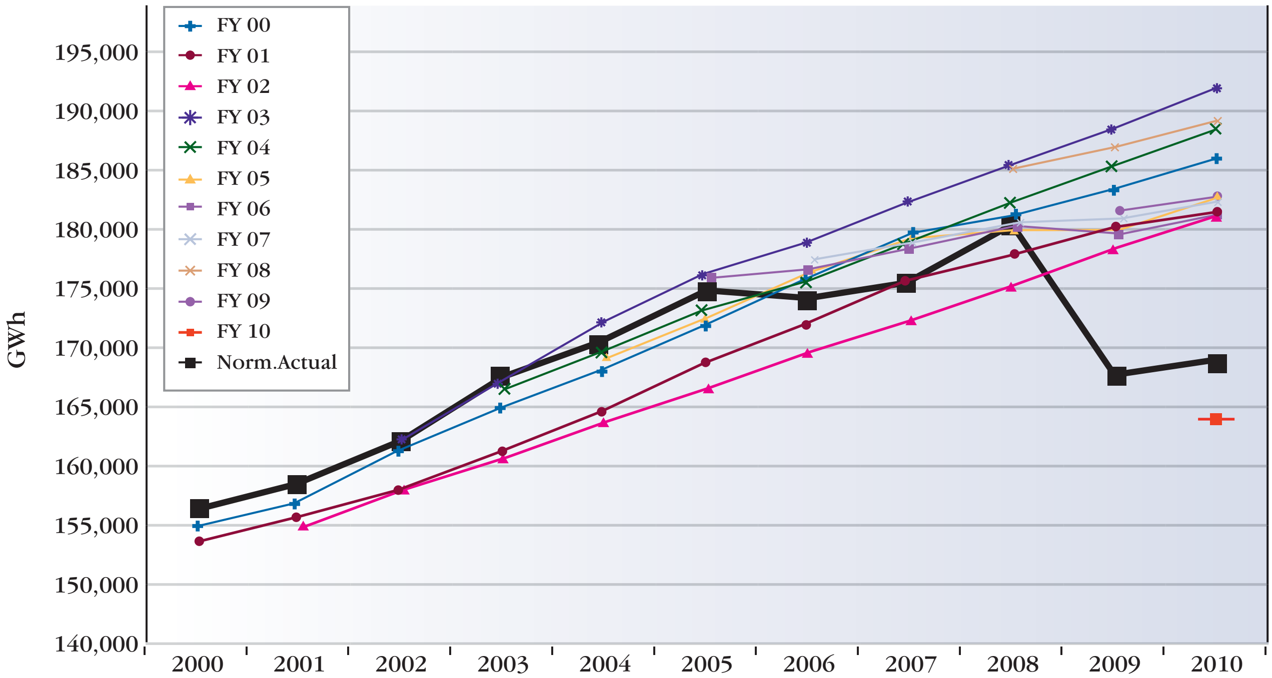


Figure 4-2 – Comparison of Actual and Forecasted Net System Requirements (GWh)

The mean annual percent error (MAPE)[1] of TVA's forecast of net system energy and peak load requirements for the 2000 to 2009 period was 1.9 percent and 2.8 percent, respectively. These include large errors in 2009 as the ramifications of the 2008 financial crisis and resulting economic slowdown impacted the economy. In the TVA service area, the most significant reductions were in the industrial sector, but it has already begun to show signs of recovery. The 2000 to 2008 MAPE was 1.1 percent for net system requirements and 2.2 percent for peak load, which is more representative of the accuracy of TVA year-in and year-out load forecasts. From informal conversations with peer utilities, TVA's MAPE of approximately 1 to 2 percent is in alignment with that of other utilities.

As mentioned previously in Section 4.1.1, while the economy in the Tennessee Valley region may be slightly stimulated by the creation of export services sold to areas outside the TVA region, future growth is expected to be lower than historical averages.

[1]MAPE is the average absolute value of the error each year; it does not allow over-predictions and under-predictions to cancel each other out.

This is a result of a number of factors, which include the impacts of the recent recession and subsequent recovery, the trend of declining U.S. manufacturing and the projected loss of some TVA customer load.

Figures 4-1 and 4-2 show the magnitude of the downturn of TVA net system requirements and summer peak loads due in part to the recession in the region. These trends are the result of a decline in energy usage by TVA customers due to a combination of factors including changes in the regional economy, improved energy efficiency and rising electricity prices.

4.1.3 Forecasts of Peak Load and Energy Requirements

To deal with the inherent uncertainty in forecasting, TVA developed a range of forecasts. Each forecast corresponds to different load scenarios. Scenarios are described in more detail in Chapter 6 – Resource Plan Development and Analysis. Forecasts of net system peak load and energy requirements for the IRP reference case and the highest and lowest scenarios are respectively shown in Figures 4-3 and 4-4. Peak load grew at an average annual rate of 1.3 percent in the Reference Case: Spring 2010, varying from 0 percent in the lowest scenario to 2 percent in the highest scenario. Net system energy requirements grew at an average annual rate of 1 percent in the IRP reference case, varying from 0 percent in the lowest scenario to 1.9 percent in the highest scenario.

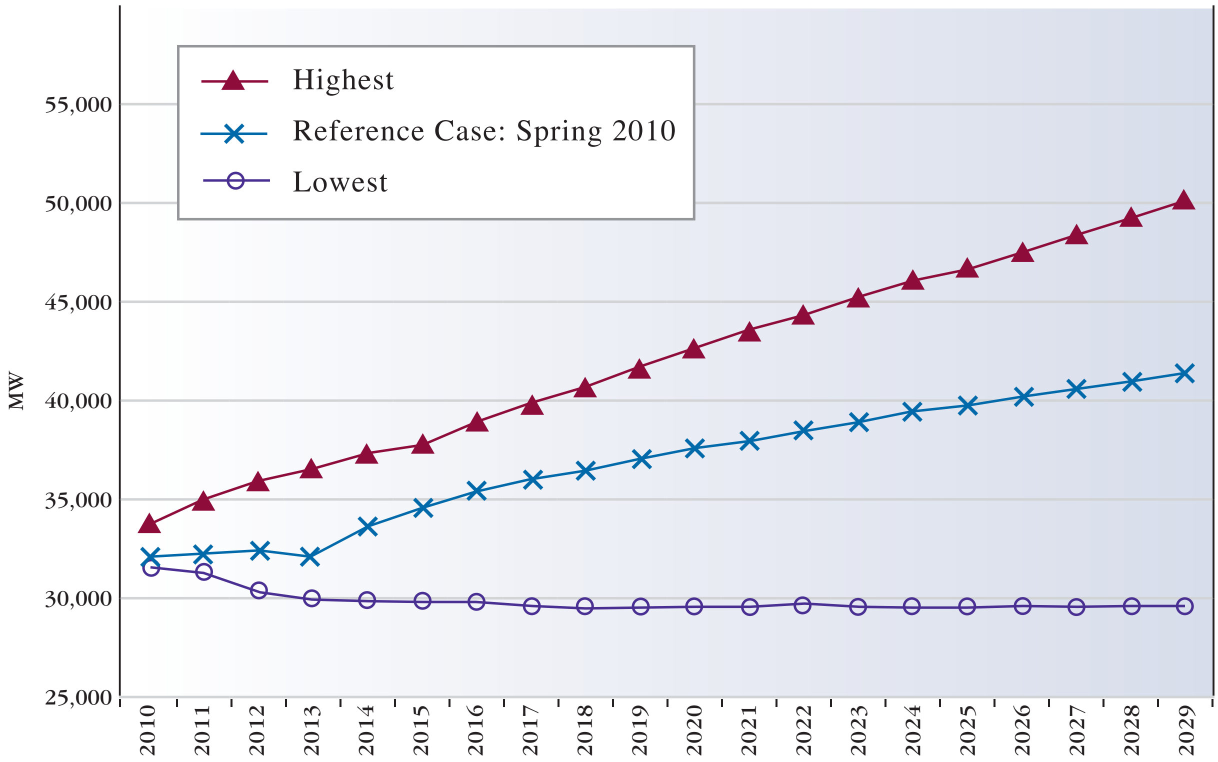


Figure 4-3 – Peak Load Forecast (MW)

The use of ranges ensured that TVA considered a wide spectrum of electricity demand in its service territory and reduced the likelihood that its plans are too dependent on the achievement of single-point estimates of demand growth that make up the midpoints of the forecasts. These ranges are used to inform planning decisions beyond pure least-cost considerations given a specific demand in each year.

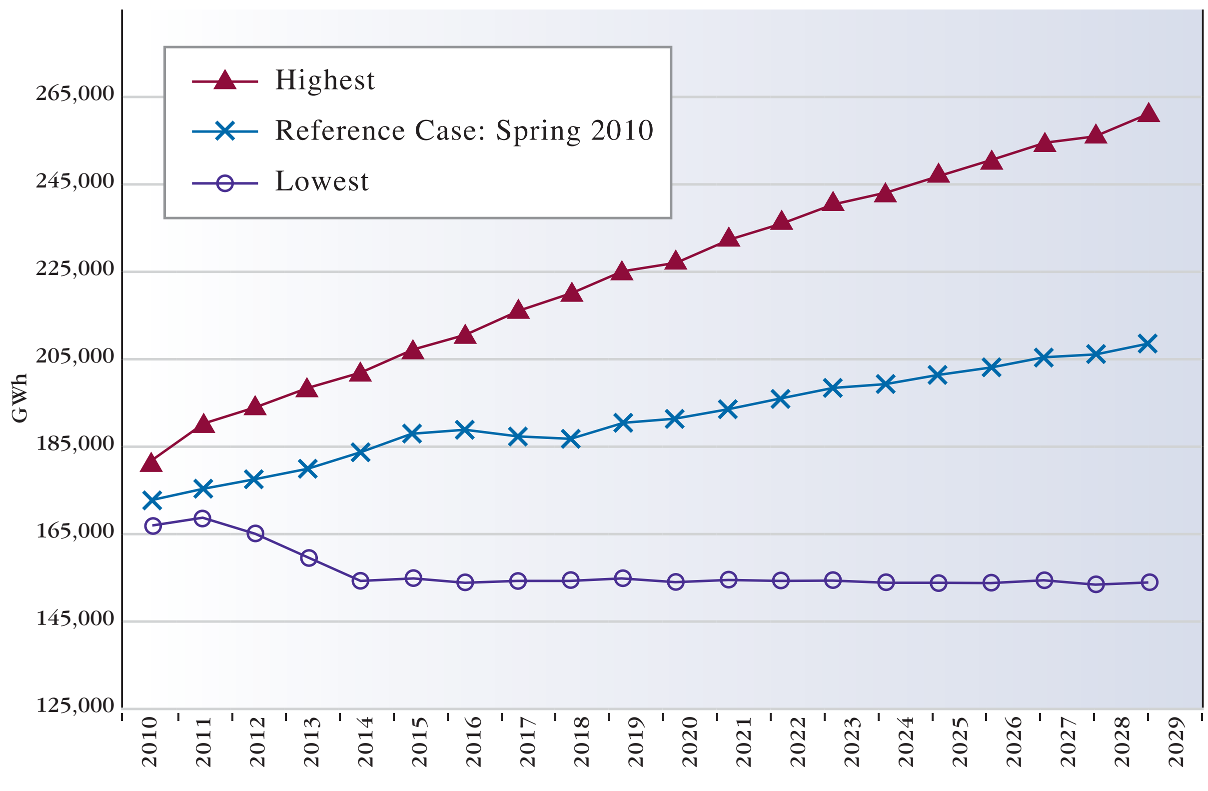


Figure 4-4 – Energy Forecast (GWh)

4.2 Determine Reserve Capacity Needs

To ensure that enough capacity is available to meet peak demand, including contingency for unforeseen events, additional generating capacity beyond which is needed to meet expected peak demand is maintained. This additional generating capacity (reserve capacity) must be large enough to cover the loss of the largest single operating unit (contingency reserves), be able to respond to moment-by-moment changes in system load (regulating reserves) and replace contingency resources should they fail (replacement reserves). Total reserves must also be sufficient to cover uncertainties such as unplanned unit outages, undelivered purchased capacity and load forecasting error.

TVA identified a planning reserve margin based on minimizing overall cost of reliability to the customer. This reserve margin was based on a stochastic analysis that considered the uncertainty of unit availability, transmission capability, economic growth and weather to compute expected reliability costs. From this analysis a target reserve margin was selected such that the cost of additional reserves plus the cost of reliability events to the customer was minimized. This target or optimal reserve margin was adjusted based on TVA's risk tolerance in producing the reserve margin used for planning studies. Based on this methodology, TVA's current planning reserve margin is 15 percent and is applied during both the summer and winter seasons.

4.3 Estimate Supply

Next, the current supply- and demand-side resources available to meet this demand were identified. TVA's generation supply consists of a combination of existing TVA-owned resources, budgeted and approved projects – such as new plant additions and updates to existing assets – and PPAs. Each type of generation can be categorized based on its degree of utilization in serving electricity demand. Generation can also be categorized by capacity, energy type and how it is measured.

4.3.1 Baseload, Intermediate, Peaking and Storage Resources

Figure 4-5 illustrates the uses of baseload, intermediate and peaking resources. Although these categories are useful, the distinction between them is not always clear. For example, a peaking unit, which is typically used to serve only intermittent but short-lived spikes in demand, may from time to time be called on to run continuously for an amount of time even though it may be less economical to do so. This may be due to transmission or other constraints. Similarly, many baseload units are capable of operating at different power levels, which gives them some characteristics of an intermediate or peaking unit. This IRP considered strategies that take advantage of this range of operations.

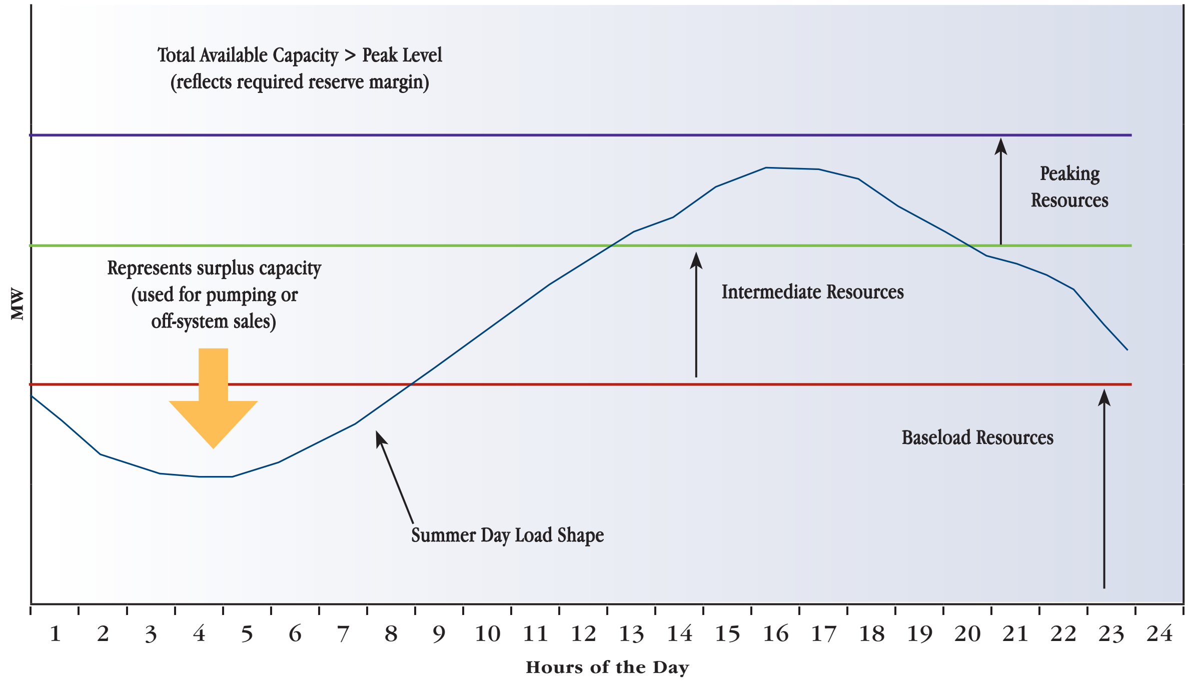


Figure 4-5 – Illustration of Baseload, Intermediate and Peaking Resources (MW)

Baseload Resources

Baseload generators are primarily used to meet energy needs during most hours of the year due to their lower operating costs and high availability. Even though baseload resources typically have higher construction costs than other alternatives, they have much lower fuel and variable costs, especially when fixed costs are expressed on a unit basis. An example of a baseload resource that provides continuous, reliable power over long periods of uniform demand is a nuclear power plant. Some energy providers may also consider natural gas-fired combined cycle plants for use as incremental baseload generators. However, given the historical tendency for natural gas prices to be higher than coal and nuclear fuel prices when expressed on a unit basis, a combined cycle unit may be a more expensive option for larger continuous generation needs. As the fundamentals of fuel supply and demand continue to change and if access to shale gas continues to grow, this relationship may change in the future.

Intermediate Resources

Intermediate resources are primarily used to fill the gap in generation between baseload and peaking needs. These units are required to produce more or less output as the energy demand increases and decreases over time, both during the course of a day and seasonally. Given current fuel prices and relative generating efficiencies, intermediate units are more costly to operate than baseload units, but cheaper than peaking units. This type of generation typically comes from natural gas-fired combined cycle plants and smaller coal-fired plants. Corresponding back-up balancing supply needed for intermittent renewable generation, such as wind or solar, also comes from intermediate resources. It is possible to use the energy generated from a solar or wind project as an intermediate resource with the use of energy storage technologies.

Peaking Resources

Peaking units are expected to operate infrequently during shorter duration, high demand periods. They are essential for maintaining system reliability requirements, as they can ramp up quickly to meet sudden changes in either supply or demand. Typical peaking resources include natural gas-fired combustion turbines (CTs), conventional hydroelectric generation and pumped-storage generation.

Storage Resources

Storage units usually serve the same power supply function as peaking units but use low-cost off-peak electricity to store energy for generation at peak times. An example of a storage unit is a pumped-storage plant that pumps water to a reservoir during periods of low demand and releases it to generate electricity during periods of high demand. Consequently, a storage unit is both a power supply source and an electricity user.

4.3.2 Capacity and Energy

Peaks in a power system are measured in terms of capacity (e.g., MW), which is the instantaneous maximum amount of energy that can be supplied by a generating plant or system. For long-term planning purposes, capacity can be specified in many forms such as nameplate (the maximum design generation), dependable (the maximum that can typically be expected in normal operation), seasonal (the maximum that can be expected during different seasons of the year) and firm (dependable capacity less all known adjustments).

Overall power system usage is measured in terms of energy (e.g., MWh or GWh). Energy is the total amount of power that an asset delivers in a specified time frame.

For example, 1 MW of power delivered for 1 hour equals 1 MWh of energy and 1,000 MWh is equal to 1 GWh. Capacity factor is a measure of the actual energy delivered by a generator compared to the maximum amount it could have produced. Assets that are run constantly, such as nuclear or coal-fired plants, provide a significant amount of energy with capacity factors of more than 90 percent. Assets that are used infrequently, such as combustion turbines, provide relatively little energy with low capacity factors of less than five percent. However, the energy they do produce is crucial because it is often delivered at peak times.

Energy efficiency can also be measured in terms of capacity and energy. Even though energy efficiency does not input power into the system, the effect is similar as it represents power that is not required from another resource. Demand reduction is also measured in capacity and energy, but unlike energy efficiency, it is not a significant reduction in total energy used.

4.3.3 TVA's Generation Mix

TVA's power generation system employs a wide range of technologies to produce electricity and meet the needs of the Tennessee Valley residents, businesses and industries. Figure 4-6 shows a breakdown of firm capacity by technology for TVA's Reference Case: Spring 2010. Figure 4-7 shows a breakdown of energy by technology for TVA's Reference Case: Spring 2010.

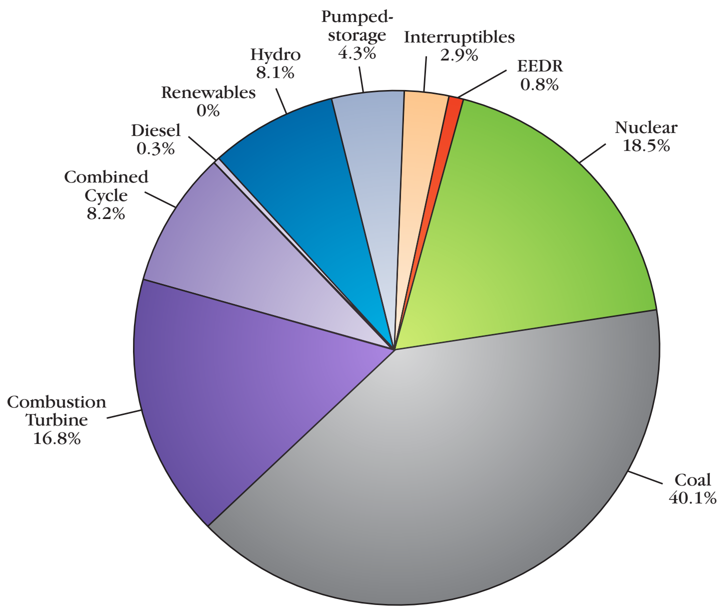


Figure 4-6 – Reference Case: Spring 2010 – Firm Capacity (MW)

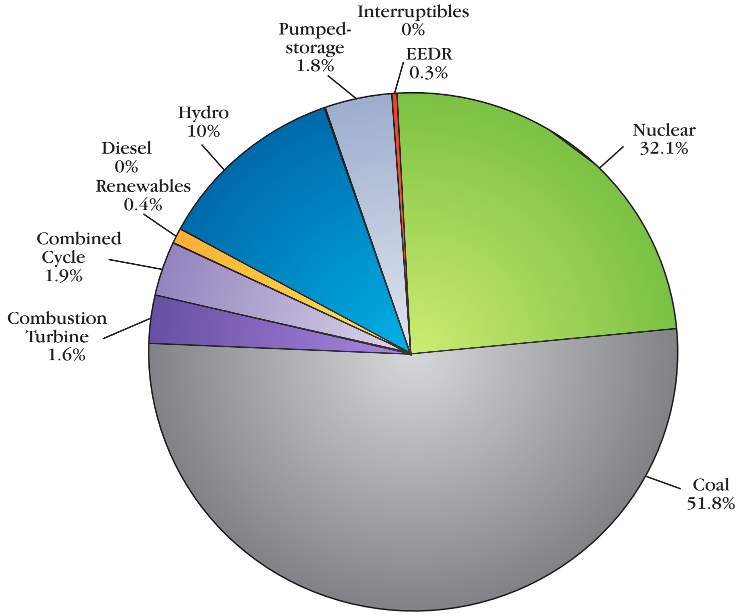


Figure 4-7 – Reference Case: Spring 2010 – Energy (GWh)

In 2010, approximately 56 percent of TVA's electricity was produced from coal-fired and natural gas-fired plants. Nuclear plants produced about 32 percent and hydroelectric plants produced approximately 12 percent. Other generation came from renewable and avoided generation sources such as EEDR.

Figure 4-8 illustrates the changing composition of existing generating resources that are assumed in planning or currently anticipated to be operated through 2029. Figure 4-8 includes only those resources that currently exist or are under contract, such as PPAs and EEDR programs, and changes to existing resources that are planned and approved, such as projects approved by TVA Board of Directors.

The total capacity of existing resources decreases through 2029 primarily because of the potential to idle coal-fired capacity. Total capacity also decreases as PPAs expire and are not extended or replaced. The renewable energy component of the existing portfolio is primarily composed of wind PPAs, which are discussed in the associated EIS. The current EEDR programs are 0.8 percent of the capacity and are also explained in further detail in associated EIS. All IRP strategies included additional renewable resources and EEDR programs beyond those depicted in Figure 4-8, as described in Chapter 7 – Draft Study Results.

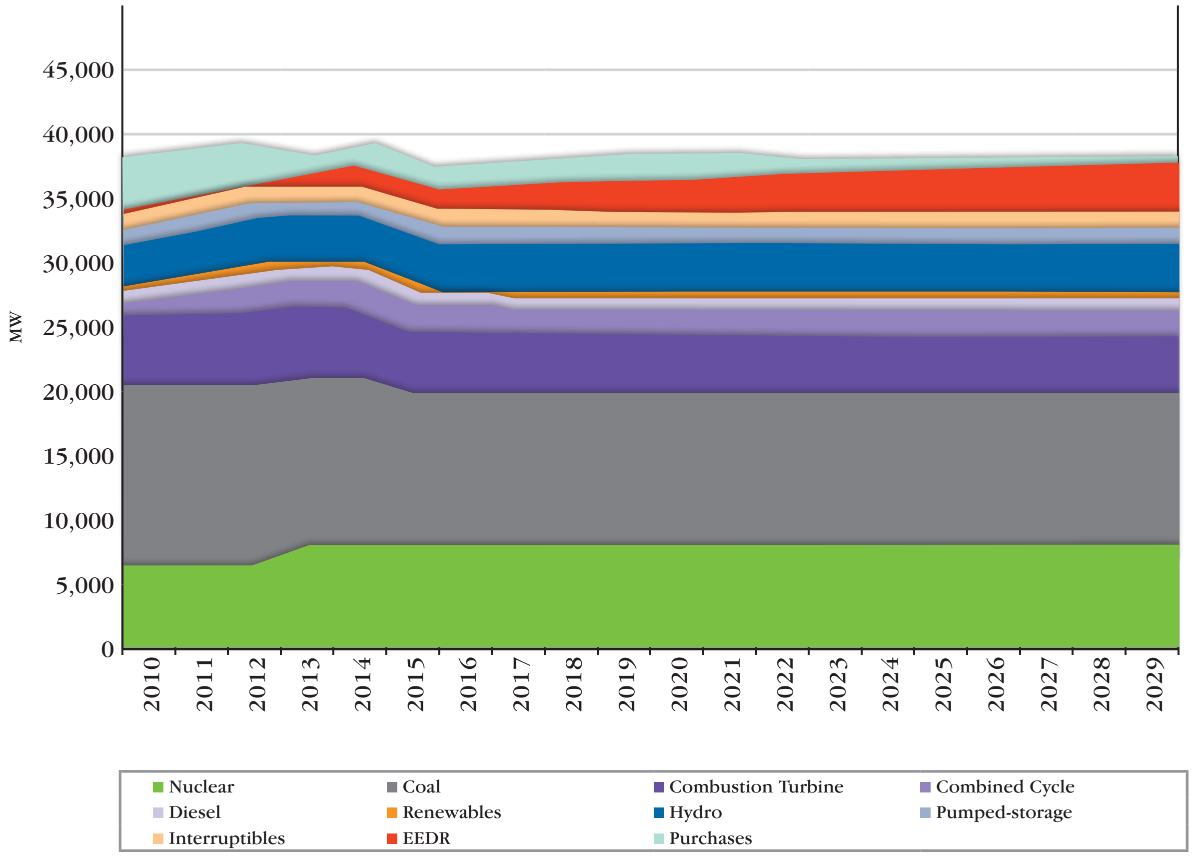


Figure 4-8 – Existing Firm Supply (MW)

The variety of resource types and the different ways they can be used provides TVA with a diverse portfolio of coal, nuclear, hydroelectric, natural gas and oil, market purchases and renewable resources. Used together, they are designed to provide reliable, low-cost power, while minimizing the risk of disproportionate reliance on any one type of resource.

4.4 Estimate the Capacity Gap

The need for power can be expressed by either the capacity or energy gap. Capacity gap is the difference, specified in MW, between the existing firm supply (Figure 4-8) and the expected firm requirements, which are the load forecasts (Figure 4-3) adjusted for any interruptible customer loads plus reserve requirements. In other words, the capacity gap is the difference between total supply and total net demand. This chapter's key reference illustrates the supply, demand and resulting capacity gap.

Energy gap is the amount of energy, specified in GWh, provided by existing resources and the new resources added in the reference case minus the energy required to meet net system requirements. Net system requirement is the required energy needed to serve the load over the entire year. It includes the energy consumed by the end-users plus distribution and transmission losses.

Figure 4-9 shows the resulting capacity gaps based on the spring 2010 peak load forecast as represented in the IRP Reference Case: Spring 2010 scenario, as well as the range corresponding to the highest and lowest capacity gap scenarios.

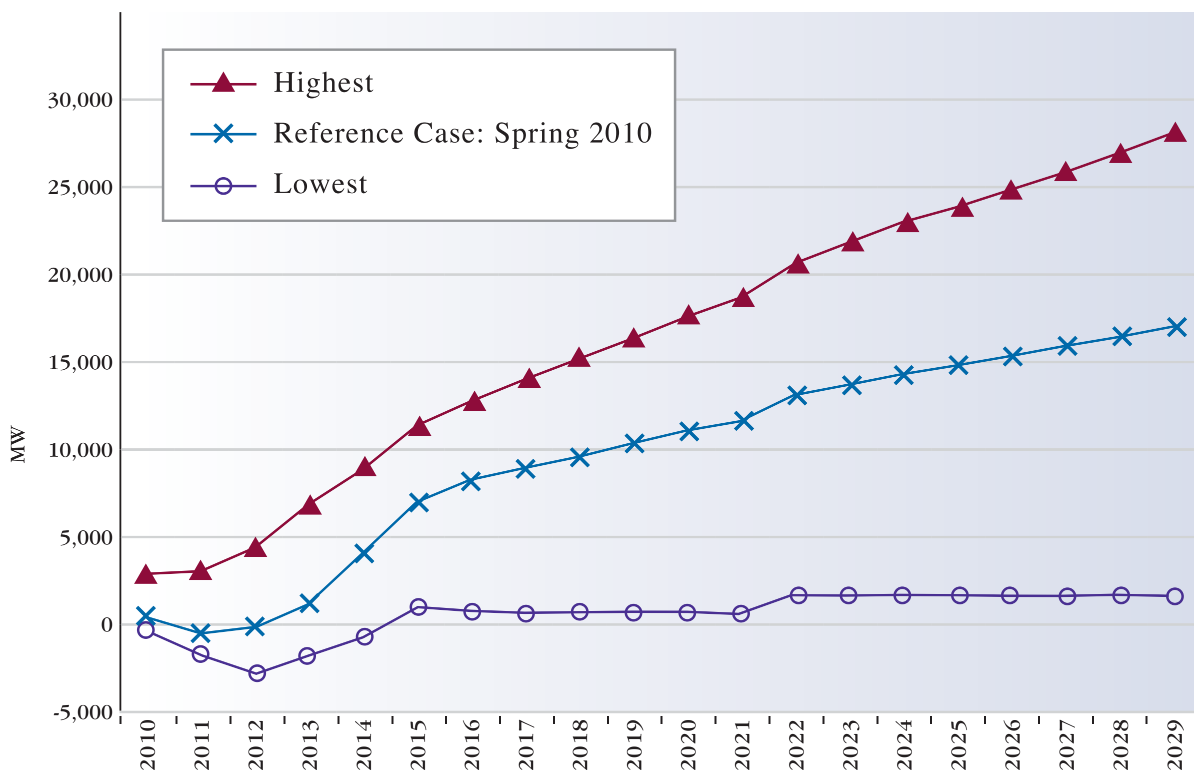


Figure 4-9 – Capacity Gap (MW)

Figure 4-10 shows the same comparison for the energy gaps.

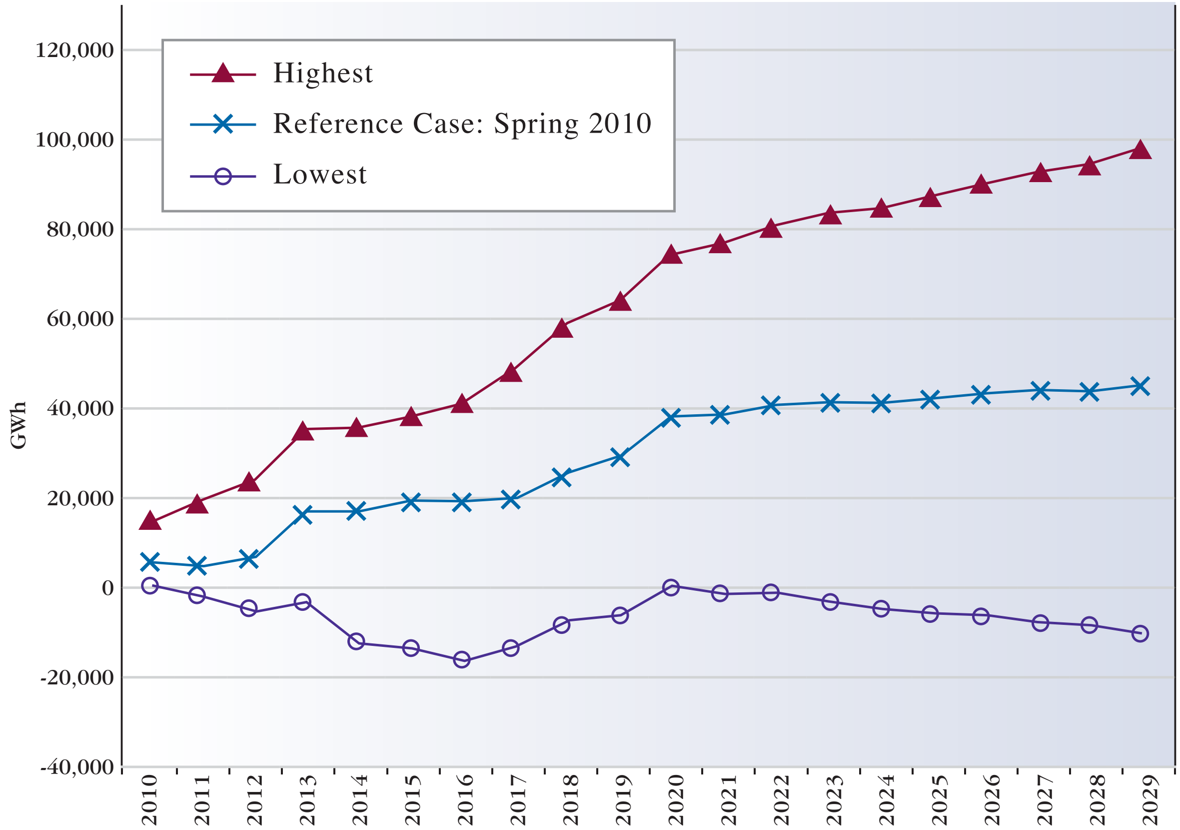


Figure 4-10 – Energy Gap (GWh)

In most scenarios and years, TVA requires additional capacity and energy of 9,600 MW and 29,000 GWh in 2019, increasing to 15,500 MW and 45,000 GWh by 2029. The alternative strategies considered by TVA to meet this gap are detailed in Chapter 7 – Draft Study Results – with the Recommended Planning Direction described in Chapter 8 – Final Study Results and Recommended Planning Direction.